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Discrimination Tests and Preliminary Preference Ratings of FROZEN CONCENTRATES for LEMONADE

U.S. DEPARTMENT OF AGRICULTURE
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This is one of a series of research projects conducted by the Division of Special Surveys under the direction of Forrest E. Clements, Head of the Division.

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DISCRIMINATION TESTS AND PRELIMINARY PREFERENCE RATINGS OF FROZEN CONCENTRATES FOR LEMONADE

Prepared in the Bureau of Agricultural Economics 1/

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INTRODUCTION

This research is one of a series of projects in which the Bureau of Agricultural Economics is cooperating with representatives of food industries in an attempt to discover consumer preferences and acceptance within a given kind of processed food. These projects have been approached with the view that there are three steps in research on the acceptance of food products 2/, 3/:

1. Discrimination tests.-Before consumers can be asked to state their preferences with respect to several variations of a food product, it must be known that they can readily detect the differences represented by the variations. These tests are best conducted on a rigidly controlled laboratory basis using subjects who are not "expert" tasters.

2. Preference tests.-These tests are used to ascertain the relative preferences for the variations of the food products that it has been found consumers can distinguish between. To be of value, such tests should be conducted on the basis of cross-section sampling of household populations.

3. Market tests.-The item most preferred is placed on the market in selected cities, thus providing a final test of the acceptance of the product in an actual selling situation.

1/ The research on which this report is based was made under authority of the Agricultural Marketing Act of 1946 (RMA, Title II). The Bureau of Agricultural Economics assumed major responsibility with the cooperation of the Lemon Products Advisory Board. The Lemon Products Advisory Board supplied the frozen concentrates for lemonade.

2/ Clements, Forrest E. Psycho-physical Methods in Market Research. Proceedings Florida State Hort. Soc., Proc. 64: 148-153, 1951.

3/ Bayton, J. A. Major Steps in Food Product Acceptance Research. Paper delivered before Virginia Academy of Sciences, May 16, 1952. (Unpublished.)

In addition to the frozen concentrates for lemonade with which this report is concerned, such research has been conducted on canned orange juice 4/ and frozen concentrated apple juice 5/, 6/. To date, however, only the latter product has been carried through the three steps outlined above.

The present project is concerned basically with 21 frozen concentrates for lemonade that vary in °Brix (degree of sweetness) and in Brix-acid ratio, which is the ratio between the sweet-sour qualities of the product. All variables other than °Brix and Brix-acid ratio were held constant. The 21 lemonades are listed in tables 1 and 2 and shown graphically in figure 1. Table 1 gives the values for the products before reconstitution; table 2 shows the values after the products had been reconstituted and they are referred to as "beverage constants." The numbers of the lemonades on the graph correspond to those in the tables.

The 21 lemonades extend considerably beyond the range that is considered commercially feasible at the present time. This range is represented by the broken line in figure 1.

Table 1.-Frozen concentrates for lemonade used in discrimination tests (values given are actual base analysis 1/

Concentrate No.	°Brix	Brix-acid ratio
1	32.22	11.4
2	31.24	13.2
3	36.70	11.3
4	37.34	13.5
5	35.96	15.5
6	41.33	11.4
7	40.00	17.4
8	42.63	13.4
9	42.10	15.5
10	47.72	13.6
11	47.70	15.4
12	47.09	17.7
13	52.82	13.7
14	53.89	15.7
15	53.44	17.8
16	51.44	19.7
17	58.96	15.8
18	59.79	17.9
19	58.20	20.0
20	65.70	18.1
21	65.26	20.2

1/ Pulp content of bases 3.8 grams per 6 ounces (retained on 20 mesh). Oil content of beverages (table 2) 0.0045 percent, by volume, recoverable, Clevenger.

4/ Bayton, J. A. Ability to Discriminate and Preferences in Regard to Canned Orange Juices that Vary in Brix-acid Ratio. Bur. Agr. Econ. 27 pp. Nov. 1950; Supplement 1, 16 pp. Jan. 1951. (Processed)

5/ Bayton, J. A. Preferences for Selected Frozen Concentrated Apple Juice. Bur. Agr. Econ. 21 pp. June 1951. (Processed)

6/ Bayton, J. A., Dwoskin, P. B., and Robert, S. A. New Concentrated Apple Juice - Its Appeal to Consumers. Bur. Agr. Econ. 48 pp. illus. Nov. 1951. (Processed

Table 2.-Frozen concentrates for lemonade used in discrimination tests (values given are beverage constants)

Concentrate No.	°Brix	Brix-acid ratio
1	6.70	11.2
2	6.49	13.0
3	7.75	10.9
4	7.90	13.2
5	7.58	15.2
6	8.87	11.1
7	8.55	16.8
8	9.19	13.1
9	9.06	15.1
10	10.47	13.1
11	10.46	14.7
12	10.31	16.9
13	11.80	13.1
14	12.08	14.9
15	11.96	16.8
16	11.43	18.7
17	13.46	15.0
18	13.69	17.1
19	13.25	18.9
20	15.37	17.1
21	15.23	19.0

BEVERAGE CONSTANTS of the FROZEN CONCENTRATES FOR LEMONADE

Used for Discrimination Tests and Preliminary Preference Ratings

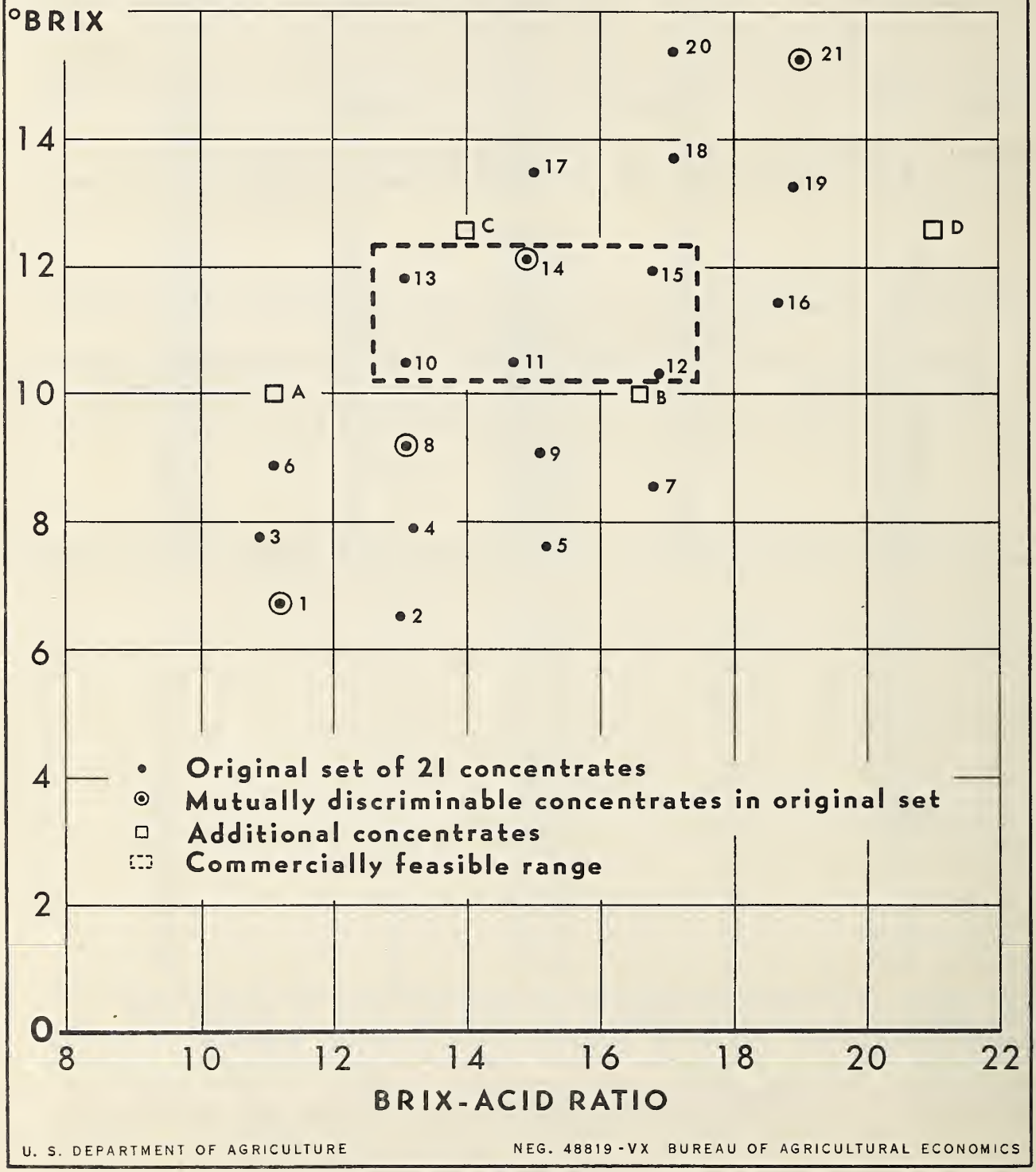

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FIGURE 1

PROCEDURE FOR DISCRIMINATION TESTS

The concentrates for lemonade were kept in frozen storage at 5° below zero °F., until they were reconstituted just before testing. In attacking the problem of discrimination, it was decided to use concentrate No. 1 (6.70 °Brix and 11.2 Brix-acid ratio 7/) as an "anchor point" and to discover where discrimination in terms of that concentrate set in. This new point would then be used and the next distinguishable point from it determined. This procedure was to be followed until a set of mutually distinguishable lemonades had been obtained.

As in this approach ability to distinguish between a given pair of lemonades was the problem, the duo-trio procedure was used. To illustrate this procedure, let us assume that we have two lemonades -- A and B. The subject is presented with three glasses, the first of which is the control lemonade. He is told that one of the other two differs from it and that the other one is exactly the same. The subject tastes the control, then tastes the next two and indicates the one he thinks differs from the first item tasted. To offset effects of position, all possible orders of presentation were randomly assigned to the subjects. These orders are:

A - A B
A - B A
B - A B
B - B A

The design of the experiment called for 18 subjects to make two judgments in testing a given pairing, making for a chi-square test based upon 36 judgments. If 12 of these judgments were incorrect, the data would not be a statistically significant indication that the two lemonades in a pairing could be distinguished by this group of subjects. The subjects were employees of the Department of Agriculture in Washington. The tests were administered in a laboratory set up in the Department's South Building. The subjects were asked not to eat for one-half hour and not to smoke for 15 minutes before coming to the laboratory.

The concentrates were reconstituted with water at approximately 35° F. The reconstituted lemonades were kept under refrigeration between tests. The lemonades were presented to the subjects in glasses; no ice was used. The temperature of the lemonades at the time of testing varied between 41° and 45° F. Each test was administered to two subjects at a time.

The reconstituted lemonades were stirred continually between tests but when a pitcher became about three-fourths empty, the remainder was discarded and a fresh pitcher of that lemonade was prepared. This was done to insure that the consistency of a reconstituted lemonade remained the same from one test to another.

Each subject took a sip of water between the two test series.

7/ Throughout the remainder of this report these values refer to beverage constants.

RESULTS OF THE DISCRIMINATION TESTS

Results of the discrimination tests are given in table 3. Each pair of lemonades is identified by number (table 2 and fig. 1), by °Brix and by Brix-acid ratio. With lemonade No. 1 (6.70 °Brix and 11.2 Brix-acid ratio) ability to detect a difference occurred when it was paired with lemonade No. 8 (9.19 °Brix and 13.1 Brix-acid ratio). With lemonade No. 8 as the control, the next discriminable point was lemonade No. 14 (12.08 °Brix and 14.9 Brix-acid ratio). This latter lemonade became the new control and lemonade No. 21 (15.23 °Brix and 19.0 Brix-acid ratio) could be distinguished from it. The four lemonades that were mutually discriminable were Nos. 1, 8, 14, and 21. (These four points are encircled in fig. 1.)

Reference to figure 1 shows that only one of these four lemonades is within what is considered to be the commercially feasible range. Our results are such as to lead to the conclusion that most "non-expert" tasters cannot easily detect the difference between two lemonades such as No. 10 (10.47 °Brix and 13.1 Brix-acid ratio) and No. 15 (11.96 °Brix and 16.8 Brix-acid ratio).

Table 3.-Results of discrimination tests of 21 frozen concentrates for lemonade (In the order in which the tests were made)

Control lemonade			Test lemonade			No. of correct judgments	No. of incorrect judgments	Total No. of judgments
No.	°Brix	Brix-acid ratio	No.	°Brix	Brix-acid ratio			
1	6.70	11.2	3	7.75	10.9	8	12	20
1	6.70	11.2	6	8.87	11.1	22	14	36
1	6.70	11.2	2	6.49	13.0	4	12	16
1	6.70	11.2	4	7.90	13.2	24	12	36
1	6.70	11.2	8	9.19	13.1	25	11	1/ 36
8	9.19	13.1	5	7.58	15.2	19	13	32
8	9.19	13.1	13	11.80	13.1	15	13	28
8	9.19	13.1	9	9.06	15.1	8	12	20
8	9.19	13.1	7	8.55	16.8	11	13	24
8	9.19	13.1	14	12.08	14.9	25	11	1/ 36
8	9.19	13.1	12	10.31	16.9	12	12	24
14	12.08	14.9	17	13.46	15.0	12	12	24
14	12.08	14.9	15	11.96	16.8	16	12	28
14	12.08	14.9	16	11.43	18.7	9	13	22
14	12.08	14.9	18	13.69	17.1	11	13	24
14	12.08	14.9	20	15.37	17.1	24	12	36
14	12.08	14.9	19	13.25	18.9	10	14	24
14	12.08	14.9	21	15.23	19.0	26	10	1/ 36

1/ The number of correct judgments is significantly greater than would be expected on the basis of chance.

Although it is current commercial practice to produce frozen concentrates for lemonade within the region indicated in figure 1, the question arises as to the significance in terms of consumer preferences, of changing the product in given directions. It is possible that a change in °Brix and Brix-acid ratio in

one direction will lead toward consumer negativism but that a change in another direction will lead toward quite favorable reactions on the part of consumers.

Because lemonades 1 and 21 were so far beyond the commercially feasible range, a new set of concentrates was prepared. These concentrates were just outside the range. The new set is designated A, B, C, and D in figure 1. The approach now became, are these four concentrates mutually distinguishable from each other? It was assumed that they were not all distinguishable from any given concentrate within the range. If, however, these four should satisfy the discrimination test, consumer preference research with the four would permit anticipation of consumer reactions should a change in any of these four directions be contemplated. The point from which such changes might be made is considered theoretically as being in the center of the commercially feasible range.

The four new concentrates were:

A. 10 °Brix and 11.1 Brix-acid ratio
B. 10 °Brix and 16.6 Brix-acid ratio
C. 12.6 °Brix and 14.0 Brix-acid ratio
D. 12.6 °Brix and 21.0 Brix-acid ratio

Results of these discrimination tests are given in table 4. Lemonades B, C, and D were mutually discriminable. Lemonade A could be distinguished from lemonade D but not from B or C. In other words, the "distance" between A and B and between A and C needs to be increased if non-expert tasters are to be expected to detect differences.

If further research is decided upon, it has been recommended that concentrates C and D be retained. Concentrate A would be replaced with a concentrate having 9 °Brix and 11.2 Brix-acid ratio. Concentrate B would be replaced with a concentrate having 9 °Brix and 18 Brix-acid ratio.

Table 4.-Results of discrimination tests of frozen concentrates for lemonade A, B, C, and D

Control lemonade			Test lemonade			No. of correct judgments	No. of incorrect judgments	Total No. of judgments
No.	°Brix	Brix-acid ratio	No.	°Brix	Brix-acid ratio			
A	10.0	11.1	D	12.6	21.0	29	7	1/ 36
A	10.0	11.1	C	12.6	14.0	21	15	36
A	10.0	11.1	B	10.0	16.6	22	14	36
B	10.0	16.6	C	12.6	14.0	25	11	1/ 36
B	10.0	16.6	D	12.6	21.0	28	8	1/ 36
C	12.6	14.0	D	12.6	21.0	25	11	1/ 36

1/ The number of correct judgments is significantly greater than would be expected on the basis of chance.

PRELIMINARY PREFERENCE RATINGS OF FROZEN CONCENTRATES FOR LEMONADE

The results presented below are preliminary for two reasons. First, our major concern was to develop an efficient method for obtaining preference ratings. In working with three items, the Method of Paired Comparisons is an efficient procedure. When, as in the present situation, four items are involved, the Method of Paired Comparisons is inadequate. Each individual would have to taste six pairs of lemonades. In any taste experiment, because of the rapid rate of adaptation of the sensory system, this is too many. Second, the results are limited because of the small numbers of subjects used in the various preference tests.

Concentrates used were 1, 8, 14, and 21.

PROCEDURES FOR THE PREFERENCE TESTS

Rank order method.-After reconstituting the four concentrates for lemonade, the four glasses were placed in a row on a table before the subject. The original position of the four concentrates varied randomly from subject to subject. For purposes of the description that follows, the four positions are designated (1) - (2) - (3) - (4).

The subject tasted the lemonade on the extreme left (1) and placed it in front of the other three:

$$\begin{matrix} (2) - (3) - (4) \\ (1) \end{matrix}$$

He then tasted the one second from the left (2) and placed it in relation to (1) in terms of "I like this one (2) better than that (1)," or "That one (1) is better than this (2)." This yielded either

$$\begin{matrix} (3) - (4) \\ (1) - (2) \end{matrix} \quad \text{or} \quad \begin{matrix} (3) - (4) \\ (2) - (1) \end{matrix}$$

Next, the subject tasted (3) and placed it in relation to the lemonade at the right in the new series being developed. If the prior step led to (1) - (2) and (3) was better than (2), the positions became (1) - (2) - (3). If the prior step gave (1) - (2) and (3) was judged not as good as (2), the subject was asked to judge (3) in relation to (1). From this emerged either

$$(3) - (1) - (2) \quad \text{or} \quad (1) - (3) - (2)$$

If the prior step gave (2) - (1), the above procedure was followed, giving either (2) - (1) - (3), (2) - (3) - (1), or (3) - (2) - (1).

The subject next tasted the last lemonade in position (4) and began by judging it in relation to the lemonade then occupying the position at the extreme right in the new series. If (4) was less preferred than the lemonade in the extreme right position, it was judged in relation to the other lemonades, going to the left until it was finally placed.

When the new order had been established the subject was asked to taste the lemonades again to verify his order of preference. He was permitted to

change the order if he wished. The scoring was 1 to 4, starting with the most preferred lemonade, the one then occupying the extreme right position.

In order to investigate the reliability of this method, each subject repeated the procedure after an interval of 3 or 4 days; 24 subjects participated.

Rating-scale method.-This procedure attempted to combine features of the Method of Constant Stimulus and a rating-scale method. Lemonade No. 8 was designated as the constant stimulus and each of the other three lemonades was judged in relation to it. After the general statement of preference had been made, the intensity of preference was ascertained by use of the rating scale shown in figure 2.

The subject was presented with two lemonades and told that the first one he would taste had an arbitrary value of 40. When he tasted the second lemonade he first judged it in terms of either "better than" or "worse than" the first. Next, using the rating scale, he assigned a score, or rating, to it. Lemonade No. 8, the constant stimulus, was presented first in half of the pairings and last in the other half. The sets of pairings were presented randomly to the subjects.

Scoring was based upon the difference in rating assigned the actual comparison lemonade, whether it occurred first or second in a given pairing. For example, if the pair judged consisted of Nos. 8 and 21, in that order of presentation to the subject, and No. 21 was "better than" and was given a rating of 70, its score became 30. If No. 21 was judged "worse than" and given a rating of 30, its score became -10. When the constant No. 8 was second in a pairing, the score remained the difference in rating based upon a score of 40 for No. 8. In this instance, if the order of presentation was No. 21 and No. 8, the subject used the arbitrary score of 40 with No. 21. If he said that No. 8 was "better than" and gave it a rating of 60, the score for No. 21 became -20. If No. 8 was judged "worse than" and given a rating of 15, the score for No. 21 was 25.

Twenty-four subjects evaluated these lemonades by both methods -- ranking and rating scale. Twelve did the ranking first and from 3 to 4 days later they did the rating-scale method. The other 12 reversed this particular procedure.

RESULTS OF THE PRELIMINARY PREFERENCE TESTS

Results of the test-retest preference rankings are shown in table 5. The rank orders were the same on both tests and the mean rankings were quite similar. Lemonade No. 14 (12.08 °Brix and 14.9 Brix-acid ratio) was most preferred. Second in preference was lemonade No. 21 (15.23 °Brix and 19.0 Brix-acid ratio). The least preferred lemonades were the two characterized by relatively low °Brix and relatively low Brix-acid ratio, with lemonade No. 1 (6.70 °Brix and 11.2 Brix-acid ratio) ranking lowest.

The degree to which the individual subjects were consistent in the initial test and in the retest is shown in table 6. These data show that 19 of the 24 subjects gave a given lemonade a rank of 4 on the two tests, 16 gave a given lemonade a rank of 3 on both tests, etc. However, three subjects who gave a lemonade (not necessarily the same one for each of the three) a rank of 4 on the first test gave it a rank of 1 on the retest. Of a total of 96 judgments made by the 24 subjects, 72 percent were identical in the two tests.

Table 5.-Test-retest preference rankings of four concentrates for lemonade (Number of subjects = 24)

Concentrate Number	Mean rank first test	Mean rank re-test
14	1.71	1.71
21	2.00	2.03
8	2.75	2.66
1	3.54	3.58

Table 6.-Individual consistency in test-retest rankings

Rank assigned to a lemonade on initial test	Rank assigned to the same lemonade on retest: 1	2	3	4	No. of subjects
4	3		2	19	24
3	1	3	16	4	24
2	3	17	4		24
1	17	4	2	1	24
No. of subjects:	24	24	24	24	

Figure 3 presents graphically the preferences for the four lemonades based upon the rating-scale method. The value, or score, assigned to each lemonade was based upon the mean difference in relation to lemonade No. 8. For example, the mean difference for lemonade No. 21, in relation to lemonade No. 8, was 8. As No. 8 was always considered as having a value of 40, the value for No. 21 is 48.

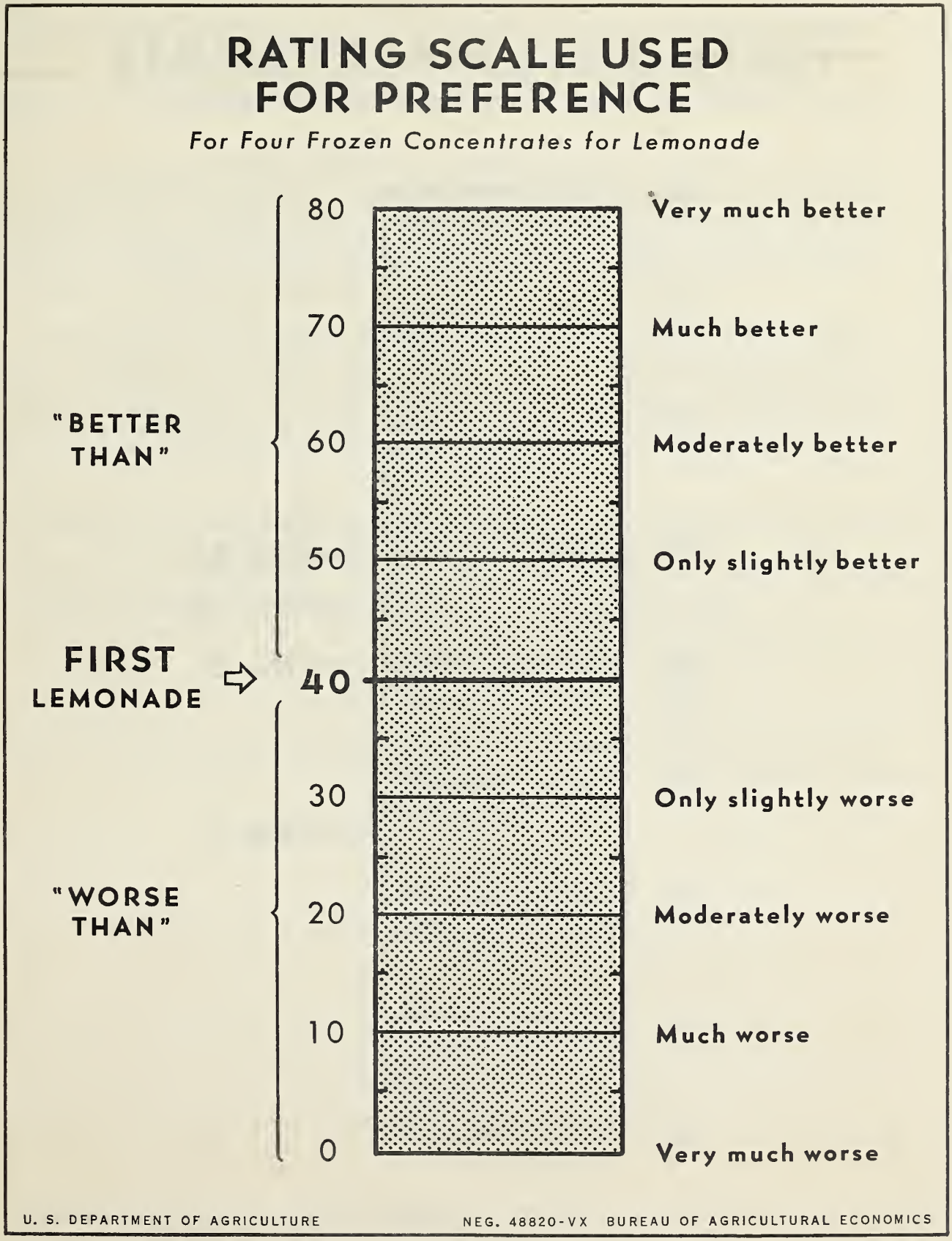
RATING SCALE USED FOR PREFERENCE
For Four Frozen Concentrates for Lemonade
80
70
60
50
40
30
20
10
0
Very much better
Much better
Moderately better
Only slightly better
Only slightly worse
Moderately worse
Much worse
Very much worse
"BETTER THAN"
"WORSE THAN"
FIRST LEMONADE
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FIGURE 2

PREFERENCE SCALE RESULTS

For Four Frozen Concentrates for Lemonade

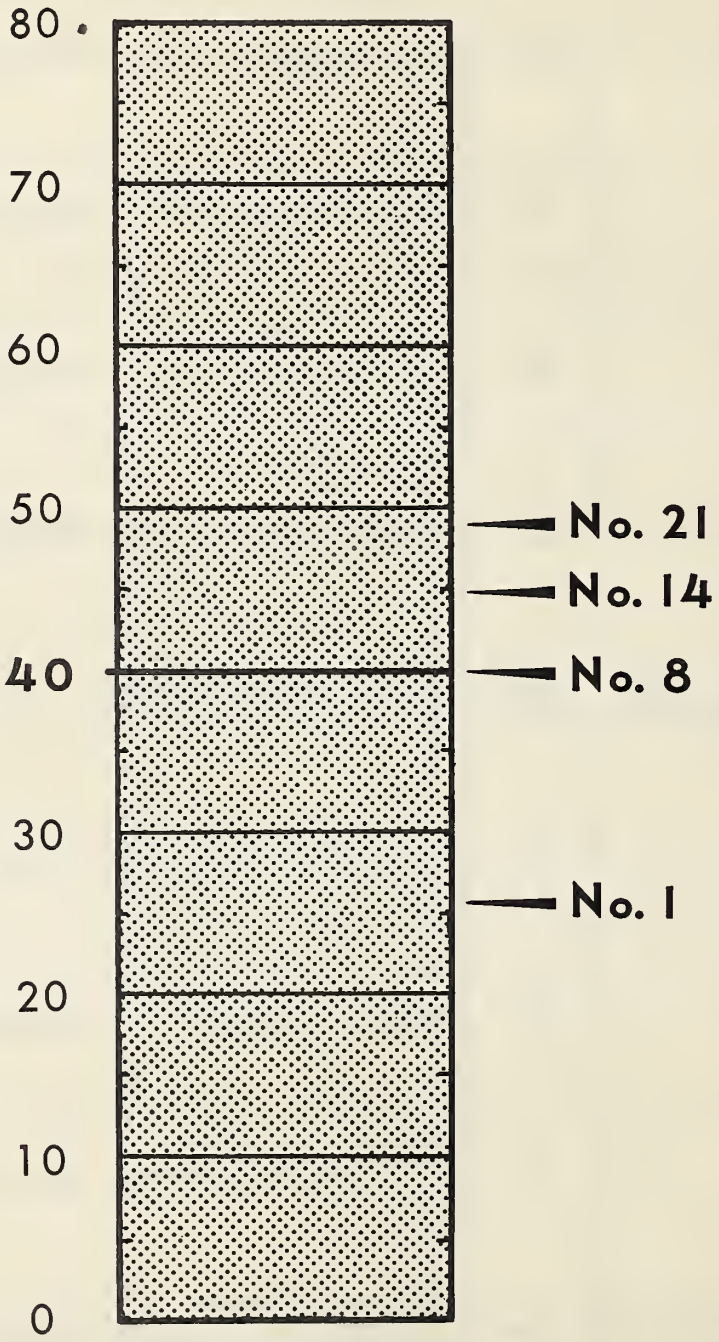

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FIGURE 3

With this method, in comparison to the rank order procedure, the position was reversed with respect to the most preferred lemonade. In the rank order method, lemonade No. 14 was first and No. 21 was second. In the rating-scale method, lemonade No. 21 was first; No. 14 was second. The results based upon the ranking method, when used by these particular subjects, were similar to those obtained from those subjects who previously had used only this method (tables 5, 7).

Altogether four independent evaluations were made of the four lemonades -- three by the ranking method and one by the rating-scale method. For any one of these evaluations, the difference between No. 14 and No. 21 was not significant. On the other hand, in the series of three evaluations based upon the ranking method, No. 14 always was first and No. 21 was second. This particular finding lends support to the view that No. 14 is preferred to No. 21.

As noted, the 24 subjects who used the rating-scale method also ranked the four lemonades. Individual performances on the two methods are given in table 8. Inspection of table 8 shows a rather high degree of inconsistency from one method to the other. In fact, of the total of 96 judgments involved, only 46 percent were identical in the two methods.

Table 7.-Preference rankings of the four concentrates for lemonade by the 24 subjects who also made rating-scale preferences

Concentrate No.	Mean rank
14	1.83
21	1.88
8	2.67
1	3.63

Table 8.-Individual consistency in the preference ranking and preference scale tests

Preference position of a lemonade from rank order method	Preference position of the same lemonade from rating-scale method: 1	2	3	4	No. of subjects
4	1	2	5	16	24
3	5	7	9	3	24
2	6	8	7	1	24
1	11	7	3	3	24
No. of subjects:	24	24	24	24	

DISCUSSION

The outstanding result of the discrimination tests is the evidence showing that most "non-expert" tasters would find it hard to detect differences among frozen concentrates for lemonade that fall within the commercially feasible range. "Experts," or those who have occasion to make frequent tests of concentrates for lemonade, claim that they can detect much smaller differences than those reported here. Two considerations must be borne in mind, however. First, the subjects of the present experiment were not experts and second, the tests were conducted under experimental laboratory conditions. One additional point should be made. The discrimination test used in these experiments requires that approximately 70 percent of the judgments must be correct if there is to be a statistically reliable indication that people can detect a difference.

The correct way to approach the problem of discrimination functions is in terms of the proportionate increases that are required to insure that the

differences will be detected. In other words, what we need to know is the ratio of the difference that gives discrimination to the original value. This is expressed in the equation:

$$pi = \frac{b - a}{a}$$

Where a = the value of the original stimulus, b = the value where discrimination occurs and pi = amount of proportionate increase.

The first "anchor point" in our discrimination tests was lemonade No. 1 (6.70 °Brix and 11.2 Brix-acid ratio). Discrimination occurred at lemonade No. 8 (9.19 °Brix and 13.1 Brix-acid ratio). The difference in °Brix is 2.49 and

$$\frac{2.49}{6.70} = 0.372$$

The difference in Brix-acid ratio is 1.9, so

$$\frac{1.9}{11.2} = 0.170$$

These data show that with a lemonade of 6.70 °Brix and 11.2 Brix-acid ratio increases of 37.2 percent in °Brix and 17 percent in Brix-acid ratio yield a discriminable lemonade.

Discrimination was obtained between lemonade No. 8 (9.19 °Brix and 13.1 Brix-acid ratio) and lemonade No. 14 (12.08 °Brix and 14.9 Brix-acid ratio). The increases here are 31.4 percent in °Brix and 13.7 percent in Brix-acid ratio. Lemonade No. 21 (15.23 °Brix and 19.0 Brix-acid ratio) could be distinguished from No. 14 (12.08 °Brix and 14.9 Brix-acid ratio). In this case there is a 26.1 percent increase in °Brix and a 27.5 percent increase in Brix-acid ratio.

Although this series of frozen concentrates for lemonade is not extended enough to permit a conclusive statement, these results lead to the tentative view that at relatively low °Brix a larger proportionate increment is necessary to bring about discrimination than is true at relatively high °Brix. Although the series in terms of °Brix does not proceed by fine enough gradations to permit the derivation of very accurate increment factors, it seems a reasonable assumption that below 10 °Brix a factor of 0.40, between 10 and 12 °Brix a factor of 0.35, and above 12 °Brix a factor of 0.30 should be safe.

Contrary to the case of °Brix where the proportionate incremental increases become smaller as °Brix rise, the higher Brix-acid ratios appear to require larger proportionate incremental increases and these incremental increases become smaller between the lower ratios.

Thus, the distance between a Brix-acid ratio of 14.9 and 19 is 4.1 points, or an increase of 27 percent of the 14.9 ratio. However, at the lower end the difference between the ratios of 11.2 and 13.1 is 1.9 points, or only 17 percent of the 11.2 ratio. Between 14.9 and 13.1, the difference is 14 percent of the 13.1 ratio. As in the case of °Brix, the Brix-acid ratios in the series are too far apart for accurate calculation of the increment factors. However, for ratios below 15 a factor of 0.20 should be fairly safe, as should be a factor of 0.30 for ratios above 15.

In setting up the tentative ratio values, rather liberal "rounding" was done. This is justified in that the basic concern in these experiments is to locate products which most "non-experts" can readily detect as different.

Figure 4 shows the four discriminable lemonades plotted with °Brix along one axis and Brix-acid ratio along the other. The points at which the four lemonades fell are encircled and connected with a broken line. It was of some interest to derive a curve of best fit from the distribution of these four lemonades on the grid. This turned out to be an exponential curve of the type $R = AB^x$ where R is the Brix-acid ratio and x is °Brix. The equation of the curve is

$$\log y = a + bx$$

where y is the Brix-acid ratio and x is °Brix. Using the values of the four lemonades found to be discriminable, the equation for the curve of best fit is

$$\log y = .87653 + .025748x$$

In figure 4 this calculated curve is represented by the solid line that has been projected beyond both the lower and upper limits of the four juices used in its calculation.

Keeping in mind the cautions regarding increment ratios previously discussed, this curve and the incremental factors mentioned above can be used tentatively to set up hypothetically discriminable lemonades anywhere along the range.

Suppose we begin with a lemonade of 9 °Brix and work up the scale. Reference to the theoretical curve shows that a lemonade of 9 °Brix should have a Brix-acid ratio of about 12.8. As we are using a factor of 0.40 for °Brix below 10, we can calculate that an increase of 40 percent, or 3.6 degrees, will be necessary for discrimination, making the next higher lemonade one of 12.6 °Brix. In the same way, a factor of 0.20 for Brix-acid ratios below 15, applied to the ratio 12.8, gives an increase of 2.56, or a lemonade with a Brix-acid ratio of 15.36. Reference to the curve shows that a lemonade of 12.8 °Brix should have a Brix-acid ratio of about 15.9 and considering the rather liberal way in which the incremental factors were rounded, this is good correspondence.

We would therefore expect, subject to actual test, that the next lemonade to be discriminated from one with 9 °Brix - 12.8 Brix-acid ratio would be a 12.6 °Brix - 15.5 Brix-acid ratio lemonade. For the next above this, we would employ a factor of 0.30 for the increase in Brix. This would be an increase of 3.78 to give a lemonade of 16.38 °Brix. According to the curve, such a lemonade would need to have a Brix-acid ratio of about 19.9. By actual calculation, with the 0.30 factor for lemonades with a ratio above 15, it would be 20.1.

Thus, theoretically the following three lemonades would be mutually discriminable.

Brix	Brix-acid ratio
9°	12.8
12.6°	15.5
16.4°	20.0

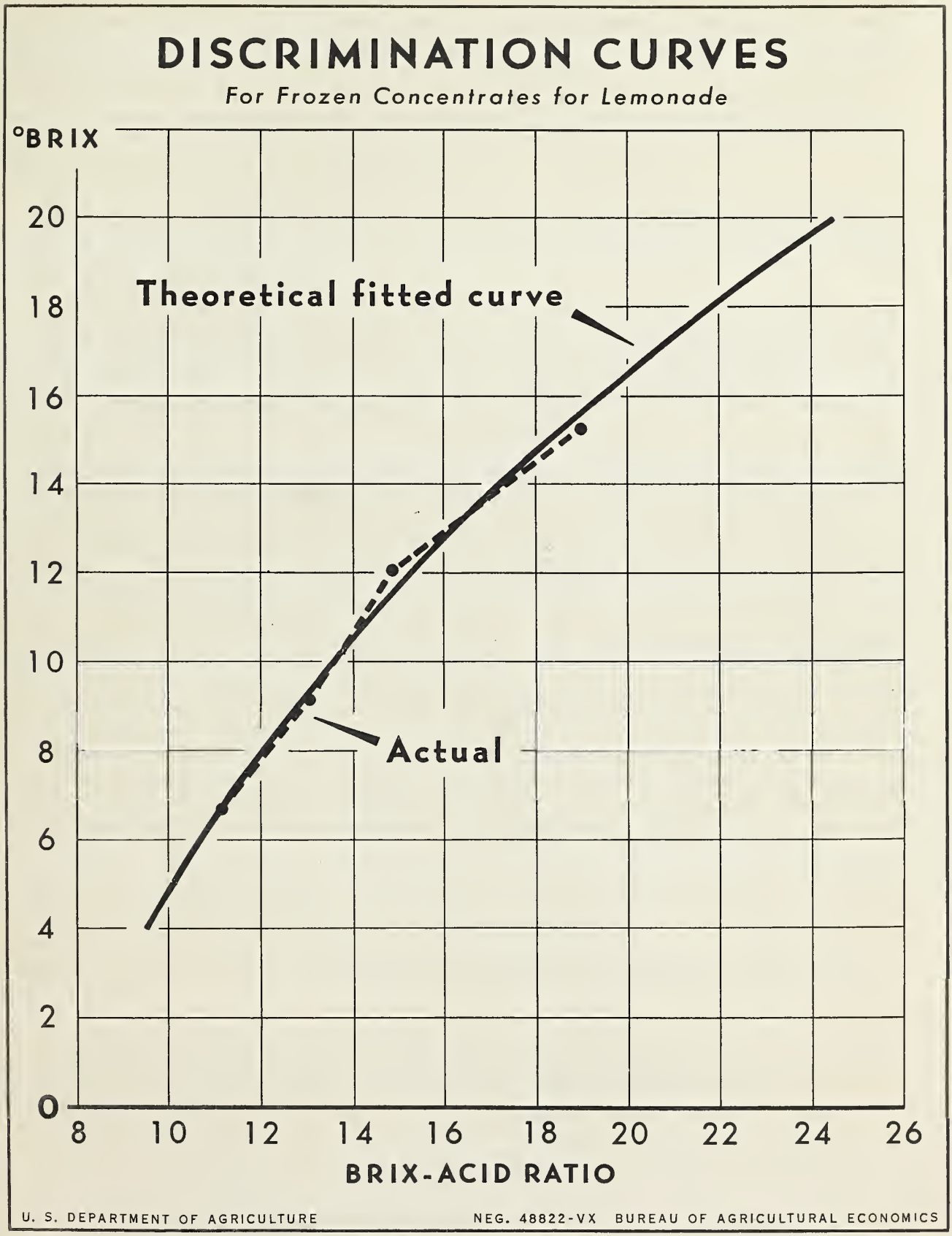
DISCRIMINATION CURVES
For Frozen Concentrates for Lemonade
°BRIX
20
18
16
14
12
10
8
6
4
2
0
Theoretical fitted curve
Actual
8
10
12
14
16
18
20
22
24
26
BRIX-ACID RATIO
U. S. DEPARTMENT OF AGRICULTURE
NEG. 48822-VX BUREAU OF AGRICULTURAL ECONOMICS

FIGURE 4

This same procedure can be employed, starting at any point on the curve and using the proper incremental factors. Although these incremental ratios are admittedly rough and their values tentative, the concept is nevertheless sound. If a series of frozen concentrates for lemonade with more finely divided gradations (°Brix 18, 18.25, 18.50, 18.75, etc.) was available, more reliable increment-ratios could be worked out. As it now stands, by working with the set of lemonades used in this study, it is not known just where discrimination occurs in the area between lemonade No. 14 and lemonade No. 21, for example. All that is known is that these two concentrates can be distinguished.

Work with a series of lemonades which are closer together both in °Brix and Brix-acid ratios would doubtless refine the accuracy of the roughly rounded incremental factors used here and would probably change somewhat the shape of the discrimination curve (though not its type).

The preference tests showed that the ranking method is more reliable than the rating-scale procedure. The latter seemed to require too much effort on the part of the subjects. Apparently, it would be difficult to administer to a sample of households in a city, especially as the very young and the semi-literate respondents would have trouble with the scoring system.

The two procedures were in agreement in rating lemonade No. 8 (9.19 °Brix and 13.1 Brix-acid ratio) as third and lemonade No. 1 (6.70 °Brix and 11.2 Brix-acid ratio) as fourth in preference. These results are a strong hint that as processors of frozen concentrate for lemonade contemplate changes in the direction of lower °Brix and a lower Brix-acid ratio than those now used as the limits of the commercially feasible range, they risk increased consumer negativism toward the product. Not only did lemonades Nos. 8 and 1 have the lowest preference ratings, but the degree of unanimity of opinion about the matter was rather high. This was demonstrated in the three sets of data based upon the rank order method. Of the 72 rank order judgments given on the three different occasions, lemonade No. 1 was assigned to the fourth, or least preferred position, 78 percent of the time. Lemonade No. 8 was given the third position in 62 percent of the judgments. Higher degrees of variability were associated with the rankings of lemonades Nos. 14 and 21. Lemonade No. 14, the first in preference, was assigned the first position in 40 percent of the judgments. Lemonade No. 21, second in preference, was given the second position in only 27 percent of the judgments.

Similar results -- a higher degree of homogeneity of opinion being associated with the less preferred concentrates -- were obtained when the standard deviations of the rating-scale scores were investigated. For lemonade No. 1 σ = 10.77, for No. 14 σ = 12.95, and for No. 21 σ = 16.94. (As lemonade No. 8 was the constant stimulus no standard deviation could be determined for it in this procedure.

The suggested directions of preference found in this preliminary research would appear to warrant more systematic and intensive investigation because of their implications for processors of frozen concentrates for lemonade. The following approach is recommended.

Assume that the most preferred frozen concentrate for lemonade is within the commercially feasible range as currently defined. Select the four concentrates for lemonade recommended on the basis of the present discrimination tests (p. 7):

A. 9.0 °Brix; 11.2 Brix-acid ratio
B. 9.0 °Brix; 18.0 Brix-acid ratio
C. 12.6 °Brix; 14.0 Brix-acid ratio
D. 12.6 °Brix; 21.0 Brix-acid ratio

Conduct preference research on these four frozen concentrates for lemonade. The results would permit processors to anticipate consumer reactions to changes in the product in any given direction, if the change were great enough to be detected.

For greatest value, this preference research should be carried on in different regions of the country on a household sampling basis, as it is possible that preferences for these products vary from one region to another.

There is a point that adds a complication for research of the kind reported here. Discrimination between two given lemonades was established when at least 67 percent of the judgments (indicating the different lemonade) were correct. There are, of course, individual differences in taste sensitivity. The above statistical requirement means that the results were greatly influenced by the extent persons with below-average taste sensitivity participated in the tests. It can be assumed that among consumers there is a small proportion, but still a large number, of people who can detect differences much less in magnitude than those utilized in this study. The reactions of this group to relatively small changes in the product could have serious influence on product acceptance For example, suppose 10 percent of consumers could detect a decrease of 15 percent in °Brix and 9 percent in Brix-acid ratio and that they disliked the resulting product to the extent that they stopped buying it. It is obvious that such behavior on the part of 10 percent of the market would be important to producers.

This raises the question as to whether research on taste preferences should not be based upon consumers with better-than-average taste discrimination ability. If the answer is that concern should be with such a group it would mean that special tests would have to be employed to locate these particular people before undertaking the preference research.

SUMMARY

1. Within the commercially feasible range, as presently defined, most people are unable to detect °Brix and Brix-acid ratio differences in frozen concentrates for lemonade.

2. In the set of 21 frozen concentrates for lemonade used in this research, four were mutually discriminable: No. 1 - 6.70 °Brix, 11.2 Brix-acid ratio; No. 8 - 9.19 °Brix, 13.1 Brix-acid ratio; No. 14 - 12.08 °Brix, 14.9 Brix-acid ratio; No. 21 - 15.23 °Brix, 19.0 Brix-acid ratio. With the exception of lemonade No. 14, all of these are beyond the limits of the commercially feasible range.

3. In ascertaining preferences for the four discriminable lemonades, a rank order procedure was found to be more efficient than the rating-scale method.

4. Preliminary preference tests showed that lemonade No. 14 was most preferred, followed by lemonades Nos. 21, 8, and 1, in that order.

5. Relative homogeneity of opinion was associated with negative attitudes toward the lemonades of low °Brix and low Brix-acid ratio.

6. It is recommended that four frozen concentrates for lemonade somewhat beyond the range of commercial feasibility be used in large-scale, regional preference research so that consumer reactions to changes in the product in given directions can be anticipated.

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